

**Upland Remedial Investigation
Work Plan
R.G. Haley International Corporation Site
Bellingham, Washington**

April 5, 2004

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UPLAND REMEDIAL INVESTIGATION WORK PLAN R.G. HALEY INTERNATIONAL CORPORATION SITE BELLINGHAM, WASHINGTON

1.0 INTRODUCTION

This work plan summarizes sampling and analysis activities associated with a Remedial Investigation (RI) of the former R.G. Haley International Corporation (Haley) wood treatment site (herein referred to as the “Site”). The location of the Site relative to surrounding physical features is shown in Figure 1.

The Site is comprised of property currently owned by Douglas Management Company (Douglas) and the State of Washington (State) (Figures 2 and 3). The inner harbor line is the boundary between the Douglas-owned and State-owned property. The State-owned property is managed by the Washington State Department of Natural Resources (DNR), and consists of both upland and aquatic (Bellingham Bay) areas. The boundary between the upland and aquatic portions of the Site is defined by the mean higher-high water line. Haley’s former wood treatment and storage activities were conducted on only the upland portion of the Site, on both the Douglas-owned and State-owned properties.

This work plan focuses only on the upland portion of the Site. Sediment sampling activities in the aquatic portion of the Site will be addressed in a separate work plan. This work plan includes a sampling and analysis plan (SAP), quality assurance project plan (QAPP), and health and safety plan (HASP). This work plan has been prepared as an attachment to the Agreed Order entered into by the Washington State Department of Ecology (Ecology) and Douglas.

The RI described in this work plan will be done in general accordance with Chapter 173-340 RCW. The upland assessment activities will focus on impacts related to past wood treating operations at the Site. The layout of the Site, including the approximate location of existing and former wood treating facilities, is shown in Figures 2 and 3.

Soil, groundwater and petroleum product samples will be obtained during this study and submitted for chemical analysis. This work plan presents a summary of Site history, sampling objectives and procedures, and analytical requirements. The data quality objectives and quality assurance/quality control (QA/QC) procedures also are presented.

2.0 SITE DESCRIPTION

The Site is located in the north ½ of Section 36, Township 38 North and Range 2 East; Latitude 48 degrees, 44 minutes, 31 seconds; Longitude 122 degrees, 29 minutes, 24 seconds; Bellingham South quadrangle (USGS, 1995). The Site is bounded by Bellingham Bay, the Cornwall Avenue Landfill (Cornwall) property, Burlington Northern Santa Fe Railroad tracks and Pine Street. The Inner Harbor Line represents the boundary between the former Haley property (current Douglas property) and the State-owned property. The Site is approximately 6 acres in size and is relatively flat. The Site is currently not in use and is zoned marine or light industrial.

Abandoned structures and facilities associated with former wood treating activities are present at the Site. When operational, the Site structures consisted of a planing and boring building where lumber was milled, two drying sheds, a kiln building, control room and shed

(unidentified use) (Figure 2). The primary wood treatment facilities included a retort, two aboveground storage tanks (ASTs) surrounded by a concrete containment wall, one underground storage tank (UST), an oil/water separator, underground surge tank and seepage pit. The control room contained a boiler room, laboratory, pentachlorophenol (PCP) storage room, and other equipment.

With the exception of the smaller drying shed and kiln building, the on-site structures have been present at the Site since the early 1950s. The smaller drying shed and kiln building were constructed between 1953 and 1969. The retort was removed from the property between 1985 and 1988. The two ASTs were also removed from their foundations after 1985. Underground facilities such as the UST, surge tank and related facilities apparently remain in place in the former wood treating area (Figure 2).

Ecology's UST files indicate that there may have been four USTs on the Haley property in the past. The files do not identify the locations of these USTs. Two of the four USTs on Ecology's list may be the UST and surge tank described above. The remaining two USTs may be a sump and oil/water separator located in the process equipment area.

Three underground pipes daylight on the shoreline bank at the Site at the approximate locations shown in Figure 2. The northeastern-most pipe appears to be a City stormwater main based on a City of Bellingham Public Works map. This stormwater main is constructed of 36-inch-diameter corrugated metal, and appears to convey runoff from City streets into Bellingham Bay. An 8-inch-diameter concrete pipe daylights on the shoreline bank southwest of the City stormwater main. The alignment and function of this underground pipe have not been established. The final pipe that daylights on the shoreline bank is constructed of wood. This rectangular wood pipe appears to be an outfall for stormwater collected from a portion of the Site, in an area west of the former wood treatment facilities (Figure 2).

3.0 POTENTIAL FUTURE LAND USE

Douglas is currently evaluating future uses of the Site. The final cleanup levels developed during the RI/FS for this Site will consider the future land use selected by Douglas.

4.0 SITE HISTORY

4.1 INFORMATION SOURCES

Site history discussions are based on information obtained from the reports and correspondence outlined in Section 11.0, and a review of Sanborn maps (1890, 1891, 1897, 1904, 1907-1913, 1913, 1913-1930, 1930-1963 and 1950) and historical aerial photographs (22 photographs dated 1944-1997). In particular, reports and letters prepared by Tetra Tech and Historical Research Associates (1995), RETEC (1997) and DNR (2002) provide significant information about historical land use and development of the Site and adjacent properties.

4.2 GENERAL SITE VICINITY

The Site includes land originally acquired from the United States by C.C. Vail, apparently in the mid-1800s, as a donation land claim. With the discovery of coal to the north of the C.C. Vail donation land claim, the Bellingham Bay Coal Company (BBCC) was formed. C.C. Vail quit

claimed his donation land claim to BBCC in 1855. BBCC operated a coal mine (Sehome Mine) at the intersection of Railroad Avenue and Myrtle Street, northeast of the Site, beginning in the 1850s until the mine was closed in 1878. The Sehome Mine ultimately extended beneath the Site vicinity and a portion of Bellingham Bay. BBCC constructed a wharf (Sehome Wharf) to deep water near Ivy Street during the period of the Sehome Mine operation. At the time of the coal mining operation, the Site and adjacent properties were tideflats of Bellingham Bay.

The owners of BBCC formed the Bellingham Bay Improvement Company (BBIC) and laid out a townsite in 1883. To facilitate the transportation of coal discovered at Lake Whatcom in 1885, the BBIC developed railroad lines, coal bunkers, a lumber mill and the Sehome Wharf on the aquatic lands between Pine Street and Beech Street. A sawmill was constructed in 1888 on what is now the Site and adjacent property (see Section 4.3).

The railroad tracks adjacent to the Site were constructed in 1890 on right-of-way acquired by the Bellingham Bay and British Columbia Railroad Company (later acquired by the Chicago, Milwaukee and St. Paul Railroad). A period of extensive development began in the Site vicinity in the 1890s. It appears that this development involved the construction of wharfs/docks and the placement of fill in the intertidal zone in the Site vicinity. It is difficult to identify the boundary between fill soil (upland) and docks/wharfs on the historical Sanborn maps. The history of fill placement also is difficult to define. Purnell (1991) reports that the Site was filled around 1950. However, other historical information suggests that the Site may have been filled to at least the current location of the paved roadway (Cornwall Avenue extension) by the 1940s or earlier. Numerous wood pilings currently present in the aquatic portion of the Site appear to be remnant features of a former wharf or railroad trestle at this location.

Tetra Tech and Historical Research Associates (1995) indicate that Brooks Manufacturing Company (Brooks) began operating in the Bellingham area in about 1919. American Fabricators, a division of Brooks, operated at “the foot of Cornwall Avenue” during the 1950s. Brooks operated two wood treatment tanks in Bellingham at least as early as 1942 and continuing through the early 1990s. Figures presented in the Tetra Tech and Historical Research Associates report show a building associated with Brooks Lumber Company/American Fabricators located southwest of the Cornwall property from the 1940s through the 1970s. Additional historical information reviewed during the preparation of this RI work plan indicates that Brooks leased and operated on a portion of the Site, probably from the 1920s into the 1960s. It is unclear whether Brooks used the Site for wood treatment or storage activities, or both.

4.3 FORMER SAWMILL

As noted above, the sawmill facilities on the Site and adjacent property were originally constructed by the BBIC in about 1888. The sawmill facilities were constructed on top of the newly filled land and wharfs/docks. In 1912, the BBIC subleased the harbor area to the Bellingham Bay Lumber Co. and the Bellingham Bay and British Columbia Railroad. In 1913, the Bellingham Bay Lumber Co. assigned its interest to the harbor area lease to Bloedel Donovan Lumber Company. The Bloedel Donovan Lumber Company purchased the sawmill in 1913 and operated it until 1947, when the Port of Bellingham (Port) purchased the mill site. Sawmill

operations terminated in 1948 (RETEC, 1997) when timber reserves were depleted. In addition to the historical sawmill facilities, the Sanborn maps from the late 1800s identify the presence of an “Electric Light Works” facility on a portion of the Site.

The sawmill is identified on the Sanborn maps dated “1913-1930” and earlier. Based on the maps, it appears that sawmill equipment at the Site was powered by steam that was generated by burning sawmill wood waste. The power source for sawmill equipment after 1930 is not known because the sawmill is not shown on the post-1930 Sanborn maps, even though the sawmill apparently operated until the late 1940s.

The Sanborn maps dated 1890-1930, in conjunction with an undated historical aerial photograph (apparently pre-1950 vintage), reveal a complex development of structures and facilities associated with the BBIC/Bloedel Donovan sawmill. The sawmill facilities included a planing mill, sorting table, dry kiln, loading platform, various sheds and an overhead electric tram linking the lumber storage area with the sorting table. The sawmill was constructed on property that encompassed the present-day Site and adjacent property to the southwest. The current boundaries of the Site and adjacent properties are not apparent on the pre-1950 historical maps and aerial photograph. One representative Sanborn map (dated 1913-1930) and two aerial photographs (pre-1950 and 1953) are presented in Appendix A. The estimated present-day boundaries of the Site and Cornwall property are shown on the historical map and photographs for reference.

The available historical maps identify a few potential sources of petroleum-related contamination associated with the former sawmill. The Sanborn maps show four different “oil houses” located in areas that later became the Site and adjacent properties, as described below. These features are also shown on the Sanborn map in Appendix A.

- 1891 and 1897 Sanborn maps – an oil house is shown on the Site at the approximate location of Haley’s former wastewater seepage pit.
- 1913 and “1913-1930” Sanborn maps – two different oil houses are shown at locations approximately 200 feet southwest of the present-day kiln building on the Site. These former facilities were located on what is currently the Cornwall site.
- “1930-1963” and 1950 Sanborn maps – an oil house is shown on the southwest side of the northeastern-most building on the Site.

The Sanborn map dated 1913-1930 also shows a machine shop, electrical shop and “auto rep’g” structure located on the northern portion of what is currently the Cornwall site. Petroleum products and other hazardous substances potentially could have been used in these structures.

The BBIC/Bloedel-Donovan sawmill burned wood waste (“hog fuel”) from the late 1800s until the late 1940s. The wood waste material was derived in part from log rafting operations adjacent to the mill. Dioxins are often produced by burning salt-laden wood waste (Ecology, 1998).

Process wastes from the Georgia-Pacific (GP) pulp and paper mill, located northeast of the Site, also are a historic local source for dioxin-related contamination. Ecology’s site hazard assessment (SHA) for the Cornwall Avenue Landfill indicated that pulp waste was disposed in

the landfill (Landau, 2003). This pulp waste, if it was derived from the local GP mill, could have introduced dioxin-related contamination to the landfill, a portion of which extends onto the Site.

4.4 FORMER WOOD TREATMENT PLANT

The early construction and operational history of the wood treatment plant at the Site is understood in general terms, although the details remain unclear. It appears that the Port leased the Site to International Crossarm Company in 1948 and renewed the lease in 1953. The lease was transferred to Haley in 1955 and renewed again in 1958 and 1960. The Port then sold the Site to Haley and American Fabricators in 1962.

Historical aerial photographs show that wood treatment facilities (retort, ASTs, etc.) were in place at the Site at least as early as April 1953, although the kiln building and southwestern drying shed were not yet present. The northeastern-most drying shed and stacks of lumber appear to be present at the Site in a June 1951 photograph. However, the wood treatment facilities that were present in the April 1953 photograph do not appear in the June 1951 photograph. It is possible that wood was treated at the site between 1948, when International Crossarm Company first leased the Site, and 1953, when wood treatment equipment first appears in aerial photographs. Wood treatment operations during this period, if conducted, could have utilized relatively limited equipment that is not visible in the June 1951 photograph.

Ecology and Environment (E&E, 1986) reports that Joslyn Manufacturing and Supply Company (Joslyn) treated wood at the Site until 1955. The relationship between Joslyn and International Crossarm Company has not been established. E&E reports that R.G. Haley then treated wood at the Site until July 1, 1985. Wood treating activities have not been performed at the Site since 1985. Douglas purchased the former R. G. Haley facility and property in 1990. The former wood treating facilities, some of which have been removed from the Site, are identified in Section 2.0.

Howard Edde (1985) summarized wood treatment procedures used at the Site by Haley. Haley produced approximately 3.2 million board-feet of treated lumber per year. The process began by first drying untreated lumber in the kiln. The kiln-dried wood was then placed in the treatment cylinder (retort), which was filled with “P-9” carrier oil containing about five percent PCP. The treating solution in the retort was heated to a temperature not exceeding 210° Fahrenheit. The retort pressure was then increased to force the preservative solution into the pore spaces of the wood, after which time the retort was drained and a vacuum was applied to remove free oil from the wood. The entire treatment cycle took approximately 4.5 hours. The freshly treated wood was removed from the retort and stored overnight northeast of the retort, followed by shipment to the customer or movement to longer term storage areas on the Site. Treated wood was likely stored in and surrounding the drying sheds, including the upland portion of the State-owned property.

The wood treatment process described above utilized several key storage vessels that held large quantities of P-9 oil, with or without the PCP additive. These vessels included the UST (17,000 gallons), underground surge tank (17,000 gallon), retort (25,000 gallons) and two ASTs

(17,000 gallons each). The treatment process involved transferring large quantities of the treatment solution between the various vessels.

The Howard Edde report identified several portions of the Site where contamination was released or potentially released. Process wastewater, including PCP-contaminated drainage fluids from the retort, was discharged to a seepage pit located near the southeast end of the kiln building (Figure 2). The seepage pit was reported to measure approximately 14 feet by 24 feet, and 5 feet deep. Unpaved ground surfaces were present beneath wood treating equipment and piping that contained wood preservative solutions. Additionally, there was no distinct separation of “process” versus “non-process” stormwater runoff from the wood treatment area. This produced a situation where potentially contaminated stormwater could have infiltrated the ground surface in unpaved portions of the Site. Stormwater runoff in the area immediately west of the former wood treatment facilities was captured by a catch basin, directed northwesterly through an underground stormwater pipe and discharged at the shoreline on State-owned property (Figure 2).

Potential surficial Site contamination is visible in the 1953 aerial photograph (Appendix A). The ground surface in the vicinity of the former retort appears to be darker than surrounding areas, and may represent surficial soil contamination. Soil staining at this location, if present, would be consistent with historical Site activities; wood preservative solutions could have dripped onto the ground surface from treated wood as it was removed from the retort and transported to the drying sheds.

Existing chemical analytical data for the Site are consistent with the historical wood treatment activities described above. PCP and petroleum-related constituents (diesel-range) are the predominant Site contaminants. Dioxins and furans also have been identified at the Site during previous studies. These constituents are often found at wood treating sites that use(d) PCP because dioxins and furans have historically been an unintended, yet common, contaminant associated with the production of PCP.

The wood treating industry commonly used two other preservatives prior to the introduction of PCP: (1) creosote, and (2) arsenic-containing solutions such as chromated copper arsenate (CCA). It was speculated by RETEC (1997) that creosote was “likely” used as a wood preservative at the Site from the late 1940s until the early 1950s. However, RETEC did not identify historical documentation to confirm this speculation. Research conducted during this RI identified one reference to creosote at the Site in Sanborn maps (1930-63). The Sanborn maps indicate that three creosote tanks were located inside the same concrete retaining wall that surrounded the more recent ASTs utilized by R.G. Haley (Section 2.0). The control room also was identified as a “creosote treating plant” on the same map. The use of PCP by R.G. Haley is well documented. It is unclear whether the Sanborn map reference to creosote was an error, or creosote was actually used at the Site for a relatively brief period, prior to the use of PCP. There is no known historical information suggesting that CCA was used at the Site.

In addition to the facilities described above, the 1950 Sanborn map identifies other potential contamination sources at the former wood treatment facility. The Sanborn map shows an oil house located on the southwest side of the planing and boring building (Figure 3). The Edde report identifies this same feature as a “fuel bin,” and indicates that a second fuel bin is located on

the northeast side of the building. The 1950 Sanborn map also shows a machine shop inside the northwestern wall of the planing and boring building.

Evidence of petroleum-related contamination was observed near the shoreline at the Site by the U.S. Coast Guard (USCG) on two different occasions. Edde (1985) reports that the USCG observed an oil sheen immediately offshore from the larger drying shed at the Site. The date on which this oil sheen was observed is not indicated in the report, but this incident obviously must have occurred prior to May 1985, which is the date of the Edde report. An oil seep was later observed on the Site shoreline and reported to the USCG on February 10, 2000. The discovery of this oil seep triggered the interim remedial activities described in Section 6.0. The approximate location of the oil seep discovered in 2000 is shown in Figure 2.

Ecology conducted a Site Hazard Assessment (SHA) of the Haley site in 1992. Ecology then ranked the Site using the Washington Ranking Method (WARM). Sites are assigned a score between one and five under the WARM, with a score of one representing those sites that pose the greatest risk to human health and the environment. The Haley site was assigned a score of 3 using the WARM system.

4.5 FORMER CORNWALL AVENUE LANDFILL

The former Cornwall Avenue Landfill is the 8-acre property located directly southwest of the Site, between Bellingham Bay and the railroad tracks. The Cornwall site is currently owned by Georgia-Pacific and the State of Washington. The portion of the Cornwall site owned by the State is leased to Georgia-Pacific and managed by DNR.

This area was historically (pre-1950s) used for log storage and wood waste disposal. The Port of Bellingham, which held a lease on the State-owned land, subleased the property to the City of Bellingham for disposal of municipal waste between about 1953 and 1965. Refuse placed at the landfill reportedly included household garbage, pulp waste, medical waste and possibly other waste. The landfill was covered by a soil layer of variable thickness at the time the landfill was closed in 1965. No landfill controls such as a liner, leachate collection or storm water runoff/runoff system exist.

Information in DNR files indicates Frank Brooks Manufacturing Company (Brooks) dumped oil at the Cornwall site after the closure of the landfill (RETEC, 1997). Brooks held leases on the landfill area and the DNR-managed portion of the former Haley Site. The files indicate that DNR considered Brooks' actions to be "unauthorized and unconstitutional." Furthermore, they were considering legal action to force Brooks to stop this activity and to cover the dumped oil. The dumping of oil at the Cornwall site by Brooks is of particular concern because Brooks treated wood in the Bellingham area. Brooks historically used both creosote and PCP to treat wood. RETEC indicated that Brooks, originally known as Ralph Turner Pipe and Tank Company until 1935, has treated wood at Iowa Street in Bellingham since 1915. This is slightly earlier than Tetra Tech's conclusion that Brooks began operating in the Bellingham area in about 1919 (Section 4.2). American Fabricators, a subsidiary of Brooks, conducted business on the Cornwall site. Tetra Tech (1995) speculated that American Fabricators/Brooks also conducted wood

treatment operations on the Cornwall site. RETEC (1997) was unable to find specific historical documentation supporting Tetra Tech's speculation.

A draft Remedial Investigation/Feasibility Study (RI/FS) has been completed for the Cornwall site between 1998 and 2002 (Landau, 2003). A summary of the primary conclusions from the Landau RI follows:

- Buried landfill refuse extends onto the Site at the estimated location shown in Figure 2.
- Petroleum-contaminated soil not related to former landfill activities was identified in the northeast corner of the former landfill site. The RI report states that sheen in groundwater identified in the area of petroleum-contaminated soil "is originating upgradient of the site, potentially from the R.G. Haley site, the GP Warehouse property upgradient of the site, the BNSF right-of-way, or from a combination of these properties."
- Contaminants of concern in groundwater are primarily limited to copper, lead, polychlorinated biphenyls (PCBs), total cyanide and NH₃-ammonia.
- Contaminants of concern in sediment are: copper, lead, silver, zinc, PCBs and bis (2-ethylhexyl) phthalate (BEP).

The preferred remedy identified in the draft FS for the Cornwall site is "containment in place with limited action," which consists of "shoreline armoring to contain solid waste along the shoreline, to provide physical filtration of groundwater and improve hydrodynamic dispersion of groundwater and surface water prior to discharge to Bellingham Bay, and to cap intertidal sediments." Institutional controls would be utilized to prohibit consumptive use of shallow groundwater and to prevent direct contact with buried refuse.

5.0 SITE SUBSURFACE CONDITIONS

5.1 GENERAL

Subsurface conditions at the Site have been evaluated during several previous studies. Among other issues, these studies evaluated Site geology, hydrogeology and hazardous substances related to historic wood treatment activities. The information summarized in this section was obtained from the following key reports prepared between 1984 and 2002:

- Howard Edde, Inc. (Edde) prepared an engineering report for Haley in 1984-85.
- Ecology and Environment (E&E) prepared a Site Inspection Report for the Environmental Protection Agency (EPA) in 1986.
- W.D. Purnell & Associates, Inc. (Purnell) performed a Phase I Environmental Site Assessment (ESA) for the State-owned portion of the Site. This assessment was performed for Georgia-Pacific in 1991.

- GeoEngineers completed limited site assessment and remedial activities for Douglas Management Company between 2000 and 2002. The results of GeoEngineers' previous studies are summarized in the following reports: "Interim Cleanup Action Plan" dated July 6, 2000, "Addendum No. 1" dated December 13, 2000, "Addendum No. 2" dated December 17, 2001, and "Interim Cleanup Action Report" dated May 20, 2002.

5.2 GEOLOGY

5.2.1 General

The most extensive assessment of subsurface conditions beneath the Site was completed by GeoEngineers in 2000. The results of GeoEngineers' study are presented in the report dated July 6, 2000. Subsurface explorations completed at the Site by GeoEngineers and others are shown in Figure 2. A summary of subsurface conditions beneath the Site, based on existing information, is presented below.

Native soil and bedrock units, as well as artificial fill materials are present beneath the Site. The important geologic units, in descending order, include the following: miscellaneous fill (including municipal landfill waste), dredge fill, native sand, glaciomarine drift and siltstone bedrock (Chuckanut Formation). These materials are shown in the interpretive cross-sections presented in Figures 4 and 5.

5.2.2 Fill Materials

Available information suggests that the Site was originally filled by constructing a dike along the approximate location of the existing shoreline. Most of the dike fill materials have been eroded, although brick, coal detritus and silty sand with gravel fill material have been observed along the shoreline bank. Similar materials also were observed in the shallow portion of most soil borings drilled near the shoreline. However, the dike fill material was not positively identified in all of the soil borings and test pits near the shoreline. Based on subsurface explorations completed by GeoEngineers, it appears that most of the dike fill has been removed by shoreline erosion during the past few decades.

The uppermost fill at the Site includes a range of materials, including construction debris (bricks, concrete and wood), silt, silty sand and gravelly sand. Landfill refuse was encountered in GeoEngineers' borings TL-B-3, TL-B-4 and TL-B-5 (see Figure 2 for exploration locations) and is likely associated with former Cornwall Avenue Landfill operations southwest of the Site. Significant thicknesses of wood debris were encountered in some of the explorations (e.g., 7-8 feet in HS-MW-7 and MS-MW-8). This wood debris consisted of sawdust and wood shavings, and likely represents waste wood material generated at the former BBIC/Bloedel Donovan sawmill (Section 4.3).

Dredge fill occurs beneath the upper fill unit and locally overlies native soil deposits. The dredge fill generally consists of fine to medium sand with shells. Lenses of silty sand and occasional wood debris also occur within the dredge fill.

5.2.3 Native Sand

A native sand unit underlies the fill at the Site. This sand unit was originally intertidal sediment prior to burial by fill. Relatively little difference exists between the native sand unit and the overlying dredge fill because the sand unit appears to be the source material for the dredge fill. The upper surface of the native sand unit, which was the mudline before filling, is often difficult to distinguish from the overlying dredge fill. The base of the native sand unit decreases in elevation in the offshore direction (toward Bellingham Bay).

5.2.4 Glaciomarine Drift

Silty glaciomarine drift underlies the native sand unit. Glaciomarine drift is common in the Bellingham area and often is more than thirty feet thick. In the on-site explorations, the drift is relatively thin (approximately 10 feet thick) and typically consists of soft to very stiff silt. The elevation of the surface and base of the glaciomarine drift decreases toward Bellingham Bay.

5.2.5 Chuckanut Formation

Siltstone bedrock of the Chuckanut Formation underlies the glaciomarine drift. The bedrock also is exposed along a broad bluff adjacent to the railroad tracks located southeast of the Site. Coal deposits in the Chuckanut Formation have been mined in the immediate Site vicinity. At some locations, the native sand and/or glaciomarine drift units are absent and fill materials directly overlie sedimentary bedrock.

5.3 SITE HYDROGEOLOGY

5.3.1 Aquifer Characteristics

The dredge fill and native sand units are the primary water-bearing formations beneath the Site. The dredge fill/native sand aquifer is underlain by a low-hydraulic conductivity unit consisting of glaciomarine drift and/or siltstone. The dredge fill/native sand aquifer is overlain by fill that generally has a relatively low hydraulic conductivity.

The depth to the groundwater surface as measured in monitoring wells completed in the dredge fill/native sand aquifer ranges from about 3.5 to 10 feet across the Site. Groundwater levels in the on-site monitoring wells have been observed to fluctuate between about 0.1 feet and 1.45 feet as a result of tidal influence. Groundwater in the dredge fill/native sand aquifer generally is unconfined at low-tide conditions. The monitoring data show that groundwater levels rise above the top of the dredge fill during mid-tide and high-tide conditions, causing semi-confined conditions.

Hydraulic conductivity values were calculated for the dredge fill/native sand aquifer from tidal monitoring data using the Jacob method as presented in Fetter (1994) assuming a specific yield value of 0.15 (unitless). Based on these calculations, hydraulic conductivity values for the dredge fill/native sand aquifer range from 22 to 50 feet/day, which is typical for a fine to medium sand aquifer (Domenico and Schwartz, 1990). Hydraulic conductivity values were also calculated for the dredge fill/native sand aquifer based on the results of grain-size analysis data

using the Fair-Hatch method as presented in Freeze and Cherry (1979). The hydraulic conductivity values calculated by this procedure ranged from 8 to 28 feet/day.

5.3.2 Groundwater Monitoring Results

GeoEngineers began conducting routine groundwater monitoring activities at the Site in January 2001. During each monitoring event, the depth to the top of free product (if any) and the depth to the water/product interface were measured in monitoring wells located north of the drying sheds. On a less frequent basis (approximately quarterly), measurements also were obtained from monitoring wells located south of the drying sheds. Groundwater table elevations adjusted for free product thicknesses and buoyancy were calculated for monitoring wells containing measurable free product. The number of measurements obtained during individual monitoring events increased as new monitoring wells and oil recovery wells were constructed at the Site.

Groundwater elevations and free product thicknesses based on Site monitoring events are summarized in Appendix B. Adjusted water table elevations ranged from about 3.27 to 11.18 feet MLLW based on measurements obtained at the Site between January 2, 2001 and January 9, 2004. Groundwater elevations at the Site have typically been highest during December and January in response to seasonal precipitation changes.

Interpolated groundwater surface elevation contours based on two monitoring events (July 19, 2000 and December 26, 2001) are shown in Figures 6 and 7. The July 2000 monitoring event was conducted prior to interim remedial actions. The December 2001 monitoring event was conducted after a sheet pile barrier was installed near the shoreline during interim remedial actions. More groundwater monitoring wells were present at the Site during the December 2001 monitoring event.

The water surface elevations obtained during the July 2000 and December 2001 monitoring events indicate that shallow groundwater beneath the Site generally flows in a northerly direction, toward Bellingham Bay. A localized depression is present in the potentiometric surface at a location near the shoreline. This depression is suggested by the groundwater elevations observed in monitoring wells TL-MW-4 and TL-MW-5A during both monitoring events (Figure 6 and 7). The more extensive groundwater elevation data obtained during the December 2001 monitoring event suggest that a localized groundwater gradient reversal exists immediately upgradient of the sheet pile barrier. It is possible that this groundwater gradient reversal also was present during the July 2000 monitoring event, but could not be defined because fewer monitoring wells were present at the Site at that time. Existing subsurface information does not provide a basis for explaining the localized depression observed in the groundwater table in the vicinity of TL-MW-4 and TL-MW-5A.

Past monitoring events indicate that a floating oil plume is present beneath the northern portion of the Site, as shown in Figures 7 through 12. Free product has been observed at the greatest frequency and thickness in monitoring wells TL-MW-2, TL-MW-3 and TL-MW-4. Free product has been observed less frequently in wells TL-MW-5/5A, TL-MW-6, RW-1, RW-3, RW-4, RW-5 and RW-6. All of these wells are located on the upland side of the sheet pile barrier, with the exception of TL-MW-6. Measured free product thicknesses at the site have ranged from about 0.01 feet to 7.55 feet.

Free product was been observed in only one monitoring well (TL-MW-6) located on the marine (northwest) side of the sheet pile barrier. Floating oil has been observed in TL-MW-6 since this monitoring well was installed (March 2001). The free product observed in TL-MW-6 was likely present at this location before the sheet pile barrier was installed. The thickness of free product in TL-MW-6, when present, ranged from 0.01 feet to 1.05 feet.

5.4 ENVIRONMENTAL CONDITIONS

The previous studies completed by GeoEngineers and others identified the presence of several constituents in soil and groundwater at concentrations exceeding Model Toxics Control Act (MTCA) Method A and/or Method B cleanup levels for unrestricted land use. The locations at which these constituents were detected at concentrations exceeding MTCA cleanup levels in Site soil and groundwater are shown in Figures 8 and 9.

The constituents detected in soil at concentrations exceeding MTCA cleanup levels included PCP, carcinogenic and non-carcinogenic polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs), and diesel- and lube oil-range hydrocarbons. Constituents detected in groundwater at concentrations exceeding MTCA cleanup levels included PCP, naphthalene, and diesel- and lube oil-range hydrocarbons. One of the groundwater samples in which PCP was detected at a concentration exceeding the MTCA cleanup level was obtained from a well point driven several feet in the intertidal zone during low tide (E&E, 1986). The approximate location of this sample (B-4) is shown in Figure 9.

GeoEngineers' previous studies identified the presence of an oil plume floating on the groundwater table in close proximity to the shoreline. The oil plume generally is limited to the State-owned property, as shown in Figures 8 and 9.

Cleanup levels have not yet been established for the Site. MTCA cleanup levels for unrestricted land use were used solely for screening purposes to identify those chemicals that warrant further study during this RI. Cleanup levels that are appropriate for this Site will be developed during the RI/FS process.

6.0 INTERIM REMEDIAL ACTIVITIES

The interim cleanup actions completed to date are summarized in the "Interim Cleanup Action Report" dated May 20, 2002. The interim cleanup actions were performed in response to an oil seep observed along the Site shoreline during February 2000. Interim actions were completed to contain the oil plume and prevent further discharge to Bellingham Bay. The interim action components included construction of a sheet pile containment barrier and an associated impermeable liner, a granular oil collection gallery, and an oil extraction system. The approximate locations of the floating oil plume, sheet pile barrier, monitoring wells and recovery wells are shown in Figure 10. A schematic cross section view of the sheet pile barrier and typical recovery well is presented in Figure 11.

Three recovery wells (RW-1 through RW-3) were constructed within the granular oil collection gallery (RW-1 through RW-3) in February 2001. Floating oil did not appear in the recovery wells, despite the continued presence of oil within nearby monitoring wells located further southeast. In July 2001, four lateral granular collection galleries (Figure 10) were constructed from the barrier toward the interior of the plume in an effort to improve the hydraulic connection between the collection gallery next to the liner and the floating oil plume. This effort also was not effective in inducing the flow of oil to the recovery wells. The site monitoring data showed that the water table elevations in the recovery wells were consistently slightly higher than water levels in monitoring wells located within the floating oil plume area. Therefore, a slight southeasterly gradient existed away from the recovery wells toward the floating oil plume, preventing oil migration to the recovery wells.

Prior to installation of the sheet piles, it was expected that the sheet pile wall would partially block the natural flow of ground water toward Bellingham Bay. The barrier was designed to allow most ground water to flow beneath the barrier within the native sand unit. The high-permeability oil collection gallery adjacent to the sheet piles appears to create a preferential pathway for migration of some of the underflow water. This results in a minor amount of upwelling within the collection gallery, resulting in the slightly higher water levels adjacent to the upgradient side of the sheet pile barrier. The magnitude of this upwelling appears to be sufficient to produce a localized reverse gradient that prevents floating oil from reaching recovery wells RW-1 through RW-3 on a consistent and significant basis.

Based on the lack of floating oil in RW-1 through RW-3, other wells were used to recover floating oil upgradient of the sheet pile barrier. This included wells originally installed for groundwater monitoring purposes (TL-MW-2, TL-MW-3 and TL-MW-4) and an additional well installed for oil recovery purposes (RW-6). These wells were connected to an oil extraction system by underground piping. The extraction system components consist of one downhole pneumatic pump and an equipment enclosure that houses a system control panel, electrical breaker box, air compressor and 240-gallon product storage tank (double-walled). The pneumatic pump is designed to recover only oil (no groundwater). The operating plan was to transfer the pump between wells based on oil recovery rates. The pump did not perform according to its specifications, ultimately recovering a high percentage of groundwater along with the oil.

Based on the poor pump performance, oil has been intermittently removed from Site wells using a portable, manually-activated peristaltic pump. Site monitoring and oil removal events have generally been conducted two to four times per month, depending on product accumulation trends in the wells. During these events, oil thickness and groundwater elevations in the vicinity of the plume are measured, and oil is removed from wells in which product thicknesses are at least 0.5 foot. Wells TL-MW-2, TL-MW-3, TL-MW-4 and TL-MW-5A typically have the greatest thicknesses of product. Approximately 135 gallons of oil was recovered through March 2004. The oil is stored in the on-site product storage tank. Approximately 900 gallons of water also is stored at the Site. This water was generated at the Site during GeoEngineers' past site assessment, interim cleanup and product recovery activities. It is comprised of groundwater and decontamination water. Monitoring data indicate that oil thicknesses have declined since

recovery efforts began and that the sheet pile wall is effectively containing the oil plume beneath the upland portion of the Site.

The interim action also included the excavation and removal of approximately 100 cubic yards of petroleum-contaminated sediment from the intertidal zone near the oil seep. The approximate sediment removal area is shown in Figures 10 and 11. The sediment was removed using a track-mounted excavator and placed in a fenced, covered enclosure at the Site. Contaminated soil generated during upland remedial activities also is stored in the covered containment area. The combined volume of soil and sediment in the containment area is estimated to be about 250 cubic yards.

7.0 PRELIMINARY CONCEPTUAL SITE MODEL

A preliminary conceptual site model (CSM) was developed for the site based on the results of site historical research and subsurface investigations (Figure 12). The CSM (not to scale) conceptually portrays contaminant sources and migration pathways beneath the Site. Some of the contaminant locations and transport pathways shown in the CSM are speculative and will be evaluated during completion of the upland and sediment investigations.

Original releases of contaminants from their sources to the Site surface and subsurface are shown in the CSM as pathways 1 and 2. Subsequent transport of contaminants at the Site surface and subsurface is represented by pathways 3 through 10. Other potential contaminant transport and exposure pathways exist in the aquatic portion of the Site (e.g., contaminant transfer from sediment or surface water to benthic organisms). The CSM will be further developed to account for these exposure pathways and receptors during preparation of the sediment sampling work plan.

The CSM was developed to reflect historical contamination sources and migration pathways related to wood treating operations. For this reason, elements of the interim remedial action are not shown in the CSM. RI/FS activities will be conducted as if the interim remedial action did not exist. For clarification, the interim remedial action was completed to address contaminant migration via pathway 10. Site observations suggest that pathway 10 has been eliminated by construction of the sheet pile barrier. It is not known at this time whether components of the interim remedial action will be part of the final remedial action.

8.0 SAMPLING AND ANALYSIS PLAN

Soil, groundwater and petroleum product samples will be obtained from the Site during this RI. These samples will be obtained from upland areas and the intertidal zone. The soil, groundwater and product samples obtained during this study will be collected using the methods described in Section 8.4.

Samples obtained during this study will be submitted to an Ecology-certified laboratory for analysis of the chemical constituents previously detected at the Site at concentrations exceeding MTCA cleanup levels, as described in Section 5.4. In addition, the samples will be tested for other chemicals (tetrachlorophenol, trichlorophenol and n-nitrosodiphenylamine) that were detected at the Site at concentrations less than published MTCA cleanup levels. To accomplish

this goal, samples obtained from the Site will be submitted for analysis of one or more of the following:

- SVOCs (including chlorinated phenols and PAHs) using EPA Method SW-846 8270C.
- PCDDs and PCDFs by EPA Method 8290 (high resolution gas chromatographs/high resolution mass spectrometry [HRGC/HRMS]).
- Diesel- and heavy oil-range hydrocarbons using Ecology Method NWTPH-Dx (with silica gel cleanup).
- Benzene, ethylbenzene, toluene and xylenes (BETX) using EPA Method 8260B.
- Extractable petroleum hydrocarbons (EPH) using Ecology-specified methodology.
- Metals (arsenic, total chromium, hexavalent chromium and copper) using EPA Methods 6000/7000 series.

BETX, EPH and metals have not been detected at the Site at concentrations exceeding MTCA cleanup levels. However, chemical analyses will be performed for BETX and EPH to satisfy MTCA test requirements for sites with petroleum releases and to enable the calculation of petroleum hydrocarbon cleanup levels under MTCA Methods B or C. Analytical tests also will be conducted for selected metals because chromated copper arsenate (CCA), although not known to be used on-site, was a chemical preservative historically used by the wood treatment industry.

NWTPH-Dx analytical results will be compared to the EPH analytical results to establish a numerical relationship between these testing procedures. This will allow subsequent use of the more cost-effective NWTPH-Dx analytical procedure to compare petroleum hydrocarbon concentrations at the site to calculated site-specific MTCA cleanup levels.

Analytical results for PCDDs and PCDFs will be presented in the RI report two different ways: as individual congeners and as toxic equivalencies (TEQ). EPA's recommended TEQ approach will be used to evaluate potential effects associated with complex mixtures of chlorinated dioxins and furans. This approach is based on the use of toxicity equivalency factors (TEFs), which, when applied, convert congener-specific concentrations into 2,3,7,8-TCDD equivalent concentrations (EPA, 1989). This approach requires multiplying dioxin and furan congener results by their respective TEFs to obtain a total 2,3,7,8-TCDD equivalent concentration in each sample. TEQ values will be calculated for individual samples using only those congeners that are detected, as recommended by Ecology (1996). This approach recommends that the total concentration for chemical groups that are expressed as the sum of individual compounds should be derived by adding the concentrations of only those individual compounds that are detected. The TEFs developed by the World Health Organization (WHO) in the June 1997 Stockholm meeting, and as summarized in Van den Berg, et al. (1998), will be used to calculate TEQ concentrations.

A general summary of the sampling and analysis plan is presented in Table 1. The specific compounds for which analytical data will be obtained are identified in the tables associated with the QAPP (Section 10.0). Proposed sampling locations are shown in Figures 13 and 14.

The analytical results obtained during this RI will be used to identify constituents of potential concern (COPC) at the Site. These COPCs will be the focus of future RI/FS activities.

8.1 SOIL

8.1.1 Sampling Objective

The soil samples in which constituents were detected at elevated concentrations during previous studies were obtained from depths ranging between about 1.5 and 10.5 feet below ground surface (bgs) (Figure 8). The analytes detected at concentrations exceeding MTCA cleanup levels included PCP, PAHs, PCDDs, PCDFs, and diesel- and lube oil-range hydrocarbons, as described earlier. Most of the soil samples that contained elevated analyte concentrations were obtained from depths near the groundwater table.

During this study, subsurface explorations will be completed in upland areas and in the intertidal zone to further evaluate the nature, extent and potential sources of soil contamination. These explorations will evaluate soil conditions in the vadose zone and within the LNAPL smear zone, as depicted in the CSM (Figure 12). The specific objective of these explorations is to further evaluate the following:

- The extent of shallow soil contamination in unpaved areas where treated wood was stored.
- The lateral extent and thickness of the LNAPL smear zone in the upland portion of the Site. This includes the area between the floating oil plume and the former wood treatment facilities. It also includes the area between the drying sheds and the southern property boundary, where freshly treated wood was removed from the retort using a tram, followed by wood storage adjacent to the tram line.
- The apparent source(s) of the floating oil plume and residual LNAPL in areas outside of the free product plume.
- The potential existence of an upgradient source for Site soil contamination, as suggested by existing groundwater monitoring data from monitoring wells HS-MW-4 and HS-MW-5.
- The lateral extent and thickness of the LNAPL smear zone in the intertidal zone.
- The potential presence of an underground surge tank that may contain hazardous materials associated with past wood treatment operations.

8.1.2 Sampling Locations, Frequency and Analyses

Approximately eight shallow soil borings will be completed in unpaved portions of the Site using a hand auger. The hand auger explorations will be generally located beneath the drying sheds and near the concrete slabs located southwest of the sheet pile barrier. The proposed shallow soil boring locations are shown in Figure 13. One soil sample from each hand auger boring will be submitted for chemical analysis. The samples will be obtained from the upper 1-foot of Site soil.

Approximately 38 deeper soil borings will be completed using direct-push drilling equipment at the approximate locations shown in Figures 13 and 14. These borings will be completed at upland on-site and off-site locations, and in the intertidal zone. The off-site borings will be completed on the adjacent Cornwall site. Soil conditions will be evaluated in all of the direct-push explorations using field screening techniques and/or analytical testing. In addition, permanent groundwater monitoring wells will be constructed in 17 of the soil borings (Section 8.2). The number of direct-push explorations completed at various locations is summarized below.

Exploration Location		Number of New Direct-Push Explorations Completed For:		Total
		Soil Sampling Only	Soil and Groundwater Sampling	
On-site	Upland	20	11	31
	Intertidal Zone	1	4	5
Off-site (upland)		0	2	2
Total		21	17	38

The direct-push borings completed solely for the purpose of evaluating soil conditions will extend to depths beneath the deepest field screening evidence of potential contamination or approximately 5 feet below the groundwater table, whichever is deeper. This procedure will ensure that the deepest extent of the LNAPL smear zone is identified in the borings (by field screening techniques). Borings completed for the construction of groundwater monitoring wells will extend to specific depths to accomplish the groundwater sampling objectives, as described in Section 8.2.

Soil samples will be obtained at approximately 2-foot-depth intervals and evaluated for the potential presence of hydrocarbon-related contamination using field screening techniques. Soil samples from the direct-push borings will be submitted for chemical analysis in general accordance with the frequency presented in Table 1. The depth of these samples will depend on field screening results and/or the depth of groundwater. It is anticipated that most of the soil samples submitted for analysis will be obtained from near the groundwater table. The other samples will be obtained at various depths to evaluate the vertical extent of soil contamination.

In addition to the soil borings described above, approximately three test pits will be excavated near the southeast end of the AST berm to evaluate the potential presence of the underground surge tank identified in the report by Edde (1985). Approximately one soil sample from each test pit will be submitted for chemical analysis. In the event that an underground tank is exposed in one or more of the test pits, the condition of the visible portion of the tank will be evaluated and the contents of the tank will be sampled (see Section 8.3).

The soil samples obtained from upland explorations will be submitted for chemical analysis of SVOCs (including chlorinated phenols and PAHs), diesel- and lube oil-range hydrocarbons, EPH, BETX, PCDDs, PCDFs and/or metals (arsenic, total chromium, hexavalent chromium and copper), as indicated in Table 1. Soil/sediment samples obtained from borings completed in the intertidal zone will be submitted for analysis of the same suite of analytes except for EPH and BETX. The primary purposes of submitting the intertidal zone soil/sediment samples for analysis are to evaluate the presence/absence of a LNAPL smear zone and to assist in the interpretation of groundwater analytical results obtained from these same explorations.

Selected soil samples from the upland explorations also will be submitted for analysis of parameters that will be used to calculate site-specific soil cleanup levels. These parameters include soil pH, bulk density, soil porosity, volumetric water content and soil fraction of organic carbon content (foc). Soil pH, bulk density, soil porosity and volumetric water content will be analyzed using ASTM methods D4972-01, 2049, D854 and 2216, respectively. The Puget Sound

Estuary Program (March, 1986) protocols will be used to analyze foc. The foc analysis will be performed on an uncontaminated soil sample obtained from at least one meter beneath the ground surface, as specified in MTCA.

8.2 GROUNDWATER

8.2.1 Sampling Objective

PCP, naphthalene, and diesel- and lube oil-range hydrocarbons were detected in groundwater beneath the Site at concentrations exceeding MTCA cleanup levels during previous studies. The greatest concentrations of groundwater constituents were detected in the immediate vicinity of the former wood treatment facilities and floating oil plume, and at some cross-gradient locations from these obvious contaminant sources (e.g. HS-MW-4). The specific source of the groundwater constituents detected in some of the “cross-gradient” wells is not known.

During this study, four quarterly groundwater monitoring events will be conducted to further evaluate the nature and extent of dissolved-phase contaminants in the shallow aquifer beneath the site, beneath the floating oil plume, and near the point where groundwater discharges to Bellingham Bay. Groundwater monitoring observations also will provide information about the lateral and vertical extent of the floating oil plume. Potential contaminant transport pathways associated with free product (floating oil plume) and dissolved-phase contaminants in the shallow aquifer are schematically represented in the CSM (Figure 12).

Groundwater samples will be obtained on a quarterly basis from monitoring wells located on-site and off-site. These activities will focus on the following key issues:

- Seasonal variations in physical and chemical groundwater conditions at the Site, including areas that have not yet been evaluated.
- Potential sources for the floating oil plume and the dissolved-phase contaminants associated with these sources.
- Potential contaminant transport pathways onto the Site from adjacent properties, or onto adjacent properties from the Site.
- The concentration and distribution of dissolved-phase contaminants beneath the LNAPL smear zone and within the shallow aquifer.
- The potential migration of dissolved-phase constituents beneath the sheet pile barrier and the intertidal zone, near the point at which groundwater from the Site discharges to Bellingham Bay.
- The extent to which natural attenuation processes may be decreasing the concentration of dissolved-phase constituents in groundwater.
- The potential existence of preferential flow paths at discrete depths within the shallow aquifer.
- The relationship between water table fluctuations and measured free product thickness and recovery volumes within the free product plume.
- The potential presence of vertical components of groundwater flow within the shallow aquifer.

8.2.2 Sampling Locations, Frequency and Analyses

A total of 17 new groundwater monitoring wells will be constructed in soil borings completed during this study, as reflected in the summary table in Section 8.1.2. These monitoring wells will be constructed at upland on-site and off-site locations and in the intertidal zone, at the proposed locations shown in Figures 13 and 14.

The new monitoring wells will be constructed in direct-push soil borings. The monitoring wells will be constructed using 1-inch-diameter polyvinyl chloride (PVC) well casing with pre-packed 3- to 5-foot slotted screens. The screens in the new wells will be installed approximately half-way between the seasonal low groundwater table and the top of the glaciomarine drift, except as described below. This well design differs from the existing wells, which have longer screens that extend both above and below the groundwater table during all seasons.

Several of the new monitoring wells will be constructed at locations that define linear transects oriented approximately parallel with ground water flow direction. These transects are identified as the east transect, west transect and Cornwall transect (Figure 13). The east and west transects extend from near the former wood treatment area into the intertidal zone. The Cornwall transect extends from the former wastewater seepage pit (existing well MW-2) to a point immediately upgradient of the landfill waste area. Information from the monitoring well transects will be used to evaluate natural attenuation processes in the shallow aquifer.

A schematic cross-section (Figure 15) conceptually presents the screen depths of monitoring wells located on the east transect. Monitoring wells on other transects will be constructed using this general approach. As shown on the schematic cross-section, the screen in the upgradient well will be installed a few feet below the seasonal low groundwater level, likely within or partially within the glaciomarine drift. A pair of side-by-side, depth-discrete monitoring wells will be constructed further downgradient. This well pair will consist of a shallow well that is screened a few feet below the seasonal low groundwater table, and a deeper well that is screened above the top of the glaciomarine drift. The downgradient end of the transect is defined by monitoring well TL-MW-11 (located immediately upgradient of the sheet pile barrier) and wells IZ-MW-3 and IZ-MW-4 (located in the intertidal zone). Data from these downgradient wells will enable sampling of groundwater below the base of the sheet pile barrier and in the intertidal zone, where groundwater discharges to surface water.

Monitoring well TL-MW-11 will be constructed inside the well casing of existing well RW-2, as shown in Figure 16. The base of the existing 10-inch-diameter well casing in RW-2 is deeper than the existing free product plume, and much of the LNAPL smear zone. Free product, if present in the casing of RW-2, will be removed prior to placing the 3.25-inch-diameter direct-push drill rods into the well casing. The top of the well screen for TL-MW-11 will be placed at approximately the same depth as the bottom of the sheet pile wall. A bentonite-cement seal will be placed from the top of the well screen to the bottom of the RW-2 well casing. This construction method for TL-MW-11 should significantly reduce exposure of the well screen and pre-pack filter to petroleum product during drilling and well construction activities.

The well screen intervals described above may be modified based on field screening results or variations in soil type. The objective will be to place the well screens at depths where conditions suggest that a preferential pathway for contaminant migration might exist.

Groundwater samples will be obtained from new and previously existing wells on a quarterly basis, as summarized below.

Monitoring Well Locations		Groundwater Sampling Points		Total
		New Monitoring Wells	Existing Monitoring Wells	
On-site	Upland	HS-MW-10, 11S, 11D, 12, 13S, 13D, 14, 15, 16; TL-MW-10, 11	HS-MW-4, 5, 6, 9; TL-MW-9, MW-2	17
	Intertidal Zone	IZ-MW-1, 2, 3, 4	None	4
Off-site (upland)		CL-MW-1S, 1D	MW-1, 5, 6, 7, and MW-1*	7
Total		17	11	28

*There are two off-site monitoring wells designated as MW-1, as described below.

The off-site wells identified above are located on the Cornwall site. This includes MW-1, MW-5, MW-6, CL-MW-1S and CL-MW-1D located southwest of the former retort and kiln building, respectively (Figure 13). It also includes two additional monitoring wells located further onto the Cornwall site that are not shown on Figure 13. These wells are identified as MW-1 and MW-7 in Figure 3-8 of the Cornwall RI/FS report (Landau, 2003). Figure 3-8 from the Landau report is shown in Appendix C. It should be noted that monitoring well MW-1 presented in Figure 3-8 of the Cornwall RI/FS report is different than monitoring well MW-1 shown southwest of the former Haley retort in Figure 13 of this work plan. These wells were installed by different entities during different studies.

During each monitoring event, groundwater levels and free product thicknesses (if present) will be measured as described in Section 8.4.2. For the first sampling event, groundwater samples will be obtained from the 28 monitoring wells identified in the above table. The groundwater samples will be submitted for chemical analysis of SVOCs, diesel- and lube oil-range hydrocarbons, EPH, BETX, PCDDs, PCDFs and/or metals (arsenic, total chromium, hexavalent chromium and copper) as indicated in Table 1. Groundwater samples also will be tested for the natural attenuation parameters identified in Table 2. The number of groundwater analyses performed will be evaluated and reduced (with Ecology concurrence) after reviewing the results from the first sampling event.

8.3 FREE PRODUCT

8.3.1 Sampling Objective

Samples of free product will be obtained from a UST located in the southeast portion of the Site and from selected monitoring wells, including wells on the Cornwall site (if free product is present). Chromatograms derived from the laboratory analysis of these samples will be reviewed to evaluate whether the product located beneath various portions of the Site and the Cornwall site appears to come from a common source, or multiple sources. These chromatograms also will be compared with chromatograms representative of dissolved-phase petroleum-related contamination in groundwater samples obtained from on-site monitoring wells and one or more off-site wells (Cornwall site).

8.3.2 Sampling Locations, Frequency and Analyses

A minimum of three free product samples will be obtained during this study. The samples will be obtained from the underground surge tank or UST in the southeast portion of the Site, monitoring well MW-1 located southwest of the former retort, a monitoring well located in the floating oil plume that contains a significant thickest free product (probably TL-MW-2, TL-MW-3 or TL-MW-4), and a well on the Cornwall site (if free product is present).

The product samples will be submitted for analysis of PCP and other SVOCs, PCDDs and PCDFs. The samples also will be submitted for analysis of diesel- and lube oil-range hydrocarbons to obtain chromatograms for fuel fingerprint/source evaluation. The product sampling and analysis described above is proposed to be a one-time event to evaluate potential contaminant sources beneath and adjacent to the Site.

8.4 GENERAL SAMPLING PROCEDURES AND EQUIPMENT

8.4.1 Soil Sampling

Hand Auger Borings. Shallow soil borings will be completed to depths of about 1.0 foot below ground surface (bgs) using a hand auger. The soil cuttings removed from each boring will be placed in a plastic bag for homogenization and field screening (see Section 8.4.6). One homogenized sample from each boring will be placed in a container provided by the analytical laboratory and submitted for chemical analysis. Each sample container will be securely capped, labeled, and placed in a cooler with ice immediately upon collection.

Power (Direct-Push) Borings. Deeper soil samples will be obtained from power borings advanced using direct-push drilling equipment. Continuous soil cores will be obtained from the direct-push borings using a 1.5-inch- or 3.25-inch-diameter split spoon sampler driven with a pneumatic hammer. The larger (3.25-inch-diameter) split spoon sampler will be used to complete those borings in which monitoring wells are to be constructed. Soil cuttings (unused soil core) from the borings will be placed in labeled 55-gallon drums.

Drilling activities will be monitored continuously by a technical representative from GeoEngineers who will observe and classify the soil encountered, and prepare detailed field notes. Soil samples obtained from the borings will be visually classified in general accordance with American Society of Testing and Materials (ASTM) D-2488. The samples also will be evaluated for the potential presence of hydrocarbon contamination using field screening techniques (see Section 8.4.6). Observations of soil and groundwater conditions, and soil field screening results for each exploration will be included in a boring log.

Soil samples will be obtained from the direct-push borings and submitted for chemical analysis. Samples will be selected for analysis based on field screening results and/or sample depth relative to groundwater depth. Samples selected for analysis will be placed in containers provided by the analytical laboratory. Each sample container will be securely capped, labeled, and placed in a cooler with ice immediately upon collection.

Test Pits. Soil samples also will be obtained from test pit excavations in the vicinity of the former wood treating facility. The test pits will be excavated using a rubber-tire backhoe or track-mounted excavator. A member of GeoEngineers' staff will observe subsurface conditions in the test pits, and classify soil in general accordance with ASTM D-2488. A log will be prepared for each test pit exploration. The log will include a summary of the soil and groundwater conditions observed, and field screening results. The test pits will be backfilled using the soil removed from the explorations.

Soil samples obtained at depths shallower than 3 feet bgs will be obtained directly from the test pit sidewalls using a stainless steel sampling spoon. Soil in the exposed test pit sidewall will not be sampled because it has been contacted by the excavator bucket. This "surficial" soil will be removed using a stainless steel sampling spoon. The "fresh" soil exposed during this process will then be sampled using a decontaminated sampling spoon or newly gloved (nitrile or latex) hand.

Test pit soil samples from depths greater than 3 feet bgs will be obtained directly from the backhoe bucket. These samples will be obtained from the center of the bucket using the procedures described above.

The planned soil boring and test pit locations described in this section may be modified if necessary to circumvent problems associated with surface access, utilities or subsurface obstructions.

8.4.2 Groundwater Sampling

Groundwater levels and free product thicknesses will be measured in each monitoring well during each monitoring event. Groundwater levels will be measured to the nearest 0.01 foot using an electric water level indicator. Fluid levels in monitoring wells that contain free product will be measured using an ORS interface probe or similar device. The water and free product levels will be measured relative to the casing rim elevations. It should be noted that the new monitoring wells will not reveal the presence of free product, if present, because the well screens will be installed below the seasonal low groundwater level. However, existing monitoring wells at the Site will identify the presence of free product because they have well screens that extend above and below the groundwater table. The direction of shallow groundwater flow beneath the Site and Cornwall property will be interpreted based on quarterly field measurements.

Groundwater samples will be obtained from selected monitoring wells not containing free product using dedicated low-flow downhole pumps and polyethylene tubing. Groundwater samples will not be submitted for analysis if visible product or sheen is present in the sample container.

Groundwater samples will be obtained using low-flow/low-turbidity sampling techniques to minimize the suspension of sediment in groundwater samples and to minimize the capture of petroleum product or sheen in the samples. A Horiba U-22 water quality measuring system (with flow-through-cell) will be used to monitor the following water quality parameters during purging: electrical conductivity, dissolved oxygen, pH, salinity, total dissolved solids, turbidity, oxidation-reduction potential and temperature. Three of these water quality parameters (dissolved oxygen,

pH and oxidation-reduction potential) also will be used to evaluate the natural attenuation of constituents in groundwater. Other natural attenuation parameters (Table 2) will be tested in a laboratory or measured in the field using a Hach DR/2010 spectrophotometer.

Ambient groundwater conditions will have been reached once these parameters vary by less than 10 percent on three consecutive measurements. The stabilized field measurements will be documented in the field log book (for subsequent use in the RI), then groundwater samples will be obtained. Purge water will be stored in labeled 55-gallon drums for subsequent characterization. Section 8.5 addresses the disposition of investigation-derived waste such as purge water.

Groundwater samples will be obtained after the wells are purged. The samples will be obtained by flowing water directly from the tubing into sample containers provided by the analytical laboratory. The samples will be free of bubbles and headspace will not be present in the containers. Each sample container will be securely capped, labeled, and placed in a cooler with ice immediately upon collection. The well casing plug and monument cover lid will be secured after each sampling event.

Samples collected for the analysis of dissolved metals (arsenic, total chromium, hexavalent chromium and copper) will be filtered using a 0.45 micrometer (μm) in-line filter.

8.4.3 Free Product Sampling

Samples of free product will be obtained from the on-site UST and selected monitoring wells using a disposable bailer or peristaltic pump and tubing. A new bailer and clean rope or pump tubing will be used to obtain each product sample from the UST and monitoring wells. The product samples will be placed in containers provided by the analytical laboratory. Each sample container will be securely capped, labeled, and placed in a cooler with ice immediately upon collection. The samples of petroleum product will be placed in a separate cooler that does not contain other environmental samples.

8.4.4 Decontamination

Drilling and sampling equipment will be decontaminated using the procedures described in the QAPP (see Section 10.3.1).

8.4.5 Sample Handling

Sample handling procedures, including labeling, container and preservation requirements, and holding times are described in the QAPP (Sections 10.2 and 10.3).

8.4.6 Field Screening

The potential presence of hydrocarbon contamination in soil samples obtained during this study will be evaluated using field screening techniques. The effectiveness of field screening varies with temperature, moisture content, organic content, soil type and type and age of contaminant. Field screening techniques will include (1) visual observation and (2) water sheen screening.

Visual screening consists of inspecting the soil for stains potentially indicative of contamination. Water sheen screening involves placing soil in water and observing the water surface for signs of sheen. The results of water sheen testing on soil samples obtained during this study will be presented in the boring logs. Sheens are classified as follows:

No Sheen (NS)	No visible sheen on water surface
Slight Sheen (SS)	Light colorless film, spotty to globular; spread is irregular, not rapid; areas of no sheen remain; film dissipates rapidly.
Moderate Sheen (MS)	Light to heavy film, may have some color or iridescence, globular to stringy, spread is irregular to flowing; few remaining areas of no sheen on water surface.
Heavy Sheen (HS)	Heavy colorful film with iridescence; stringy, spread is rapid; sheen flows off the sample; most of water surface may be covered with sheen.

8.4.7 Surveying

Each exploration location will be marked following completion to allow surveying by a professional land surveyor registered in Washington State. The surveyors will obtain only vertical control at the exploration locations. Ground surface elevations at each exploration location will be measured to the nearest 0.01-foot, and elevations will be reported relative to the City of Bellingham datum. Monitoring well casing rim elevations will be surveyed to the nearest 0.01-foot for all new and existing wells included in the sampling and monitoring program. A technical representative of GeoEngineers will identify the horizontal location of explorations on a Site plan.

8.5 DISPOSITION OF INVESTIGATION-DERIVED MATERIALS

8.5.1 Soil Disposition

Soil removed from the test pit excavations will be replaced in the excavations. Soil cuttings from borings completed during this study will be placed in labeled and sealed 55-gallon drums. The drums will be stored temporarily in an existing containment area until appropriate disposal is identified.

8.5.2 Groundwater and Decontamination Water Disposal

Purge water removed from the monitoring wells and decontamination water generated during all sampling activities will be stored on-site in labeled 55-gallon drums. The drums of water will be stored temporarily in the existing containment area.

8.5.3 Disposition of Exploration-Derived Waste

Incidental waste generated during sampling activities may include gloves, Tyvek suits, spent respirator cartridges, disposable bailers, plastic sheeting, paper towels and similar expended and discarded field supplies. These materials also will be temporarily stored in a 55-gallon drum in the containment area.

8.6 SCHEDULE

The schedule for planned field activities and reporting is presented in Table 3.

9.0 TERRESTRIAL ECOLOGICAL RISK

The remedy for the upland portion of the Site will not be selected until the RI/FS process is completed. However, it is reasonable to anticipate that one element of the preferred remedy will be an upland cap. This is a likely outcome based on other wood treatment sites in the Puget Sound region where cleanup alternatives have been evaluated during completion of a formal RI/FS under regulatory oversight. Examples of possible upland caps at the Site include buildings, paved cargo/parking lots, and buried liners beneath landscaping or green space areas.

An upland cap, if constructed, would likely qualify the Site for an exclusion from the terrestrial ecological evaluation process under WAC 173-340-7491 (1)(b). For this reason, a terrestrial ecological risk evaluation will not be completed at this time. It will be necessary to reconsider the need for a terrestrial ecological evaluation if it is determined that the upland portion of the Site will not ultimately be capped.

10.0 QUALITY ASSURANCE PROJECT PLAN

This Quality Assurance Project Plan (QAPP) was developed for Upland RI exploration activities at the Site. In addition to the QAPP, the remaining sections of this upland RI work plan provide the framework for completing the data collection and analytical phases of the project. The QAPP serves as the primary guide for the integration of quality assurance (QA) and quality control (QC) functions into project activities. The QAPP presents the objectives, procedures, organization, functional activities, and specific quality assurance and quality control activities designed to achieve data quality goals established for the project. This QAPP is based on guidelines specified in Washington Administrative Code (WAC) 173, Chapter 173-340 and Ecology guidance (February 2001).

Throughout the project, environmental measurements will be conducted to produce data that are scientifically valid, of known and acceptable quality, and meet established objectives. QA/QC procedures will be implemented so that precision, accuracy, representativeness, completeness, and comparability (PARCC) of data generated meet the specified data quality objectives.

This QAPP will be used during the following three stages of the RI:

- Project Planning – to present the plans for project execution from a quality assurance viewpoint.
- Project Implementation – to act as a guide for quality assurance reviews and as the specifications for assessing the quality of data generated.
- Project Completion – to serve as a basis for determining whether the project has attained established goals.

10.1 PROJECT ORGANIZATION AND RESPONSIBILITY

The key project personnel are shown in Table 4. Descriptions of the responsibilities, lines of authority and communication for the key positions to quality assurance and quality control are provided below. This organization facilitates the efficient production of project work, allows for an independent quality review, and permits resolution of any QA issues before submittal.

10.1.1 Project Leadership and Management

Within GeoEngineers, Inc. there are two levels of project responsibility; the Principal-in-Charge and Project Manager. The Principal-in-Charge is ultimately responsible for technical quality, schedule, budget and staff resources for the project. This person is responsible to Douglas and Perkins Coie for fulfilling contractual and administrative control of the project. Jim Miller is the Principal-in-Charge.

The Project Manager's duties consist of providing concise technical work statements for project tasks, selecting project team members, determining subcontractor participation, establishing budgets and schedules, adhering to budgets and schedules, providing technical oversight, and providing overall production and review of project deliverables. Brick Spangler is the Project Manager for activities at the Site.

10.1.2 Field Coordinator

The Field Coordinator is responsible for the daily management of activities in the field. Specific responsibilities include the following:

- Provides technical direction to the field staff.
- Develops schedules and allocates resources for field tasks.
- Coordinates data collection activities to be consistent with information requirements.
- Supervises the compilation of field data and laboratory analytical results.
- Assures that data are correctly and completely reported.
- Implements and oversees field sampling in accordance with project plans.
- Supervises field personnel.
- Coordinates work with on-site subcontractors.
- Schedules sample shipment with the analytical laboratory.
- Monitors that appropriate sampling, testing, and measurement procedures are followed.
- Coordinates the transfer of field data, sample tracking forms, and log books to the Project Manager for data reduction and validation.
- Participates in QA corrective actions as required.

The Field Coordinator for RI exploration activities at the Site is Brick Spangler.

10.1.3 Quality Assurance Leader

The GeoEngineers project Quality Assurance Leader is under the direction of Jim Miller, who is responsible for the project's overall QA. The Project QA Leader is responsible for coordinating QA/QC activities as they relate to the acquisition of field data. The QA Leader has the following responsibilities:

- Serves as the official contact for laboratory data QA concerns.
- Responds to laboratory data, QA needs, resolves issues, and answers requests for guidance and assistance.
- Reviews the implementation of the QAPP and the adequacy of the data generated from a quality perspective.
- Maintains the authority to implement corrective actions as necessary.
- Reviews and approves the laboratory QA Plan.
- Evaluates the laboratory's final QA report for any condition that adversely impacts data generation.
- Ensures that appropriate sampling, testing, and analysis procedures are followed and that correct quality control checks are implemented.
- Monitors subcontractor compliance with data quality requirements.

The Project QA Leader is Rob Smith of GeoEngineers.

10.1.4 Laboratory Management

The subcontracted laboratories conducting sample analyses for this project are required to obtain approval from the QA Leader before the initiation of sample analysis to assure that the laboratory QA plan complies with the project QA objectives. The Laboratory's QA Coordinator administers the Laboratory QA Plan and is responsible for quality control (QC). Specific responsibilities of this position include:

- Ensure implementation of the QA Plan.
- Serve as the laboratory point of contact.
- Activate corrective action for out-of-control events.
- Issue the final QA/QC report.
- Administer QA sample analysis.
- Comply with the specifications established in the project plans as related to laboratory services.
- Participate in QA audits and compliance inspections.

The chemical analytical laboratory Quality Assurance Coordinator is Greg Salata at Columbia Analytical Services, Inc. in Kelso, Washington and Jeff Gerdes at North Creek Analytical, Inc. in Bothell, Washington.

10.1.5 Health and Safety

A site-specific health and safety plan (HASP) was prepared for previous work at the site. This same HASP will be used for RI field activities and is presented in Appendix D. The Field Coordinator will be responsible for implementing the HASP during sampling activities. The Project Manager will discuss health and safety issues with the Field Coordinator on a routine basis during the completion of field activities.

The Field Coordinator will conduct a tailgate safety meeting each morning before beginning daily field activities. The Field Coordinator will terminate any work activities that do not comply with the HASP. Companies providing services for this project on a subcontracted basis will be responsible for developing and implementing their own HASP.

10.2 DATA QUALITY OBJECTIVES

The quality assurance objective for technical data is to collect environmental monitoring data of known, acceptable, and documentable quality. The QA objectives established for the project are:

- Implement the procedures outlined herein for field sampling, sample custody, equipment operation and calibration, laboratory analysis, and data reporting that will facilitate consistency and thoroughness of data generated.
- Achieve the acceptable level of confidence and quality required so that data generated are scientifically valid and of known and documented quality. This will be performed by establishing criteria for precision, accuracy, representativeness, completeness, and comparability, and by testing data against these criteria.

Specific data quality objectives (DQOs) to evaluate data quality and usability are provided in the sections below.

10.2.1 Analytes and Matrices of Concern

Samples of soil, groundwater and free petroleum product will be collected during upland exploration activities. Table 1 summarizes the sample matrices, analyses to be performed and number of analyses for each study area at the Site.

10.2.2 Detection Limits

Analytical methods have quantitative limitations at a given statistical level of confidence that are often expressed as the method detection limit (MDL). Individual instruments often can detect but not accurately quantify compounds at concentrations lower than the MDL, referred to as the instrument detection limit (IDL). Although results reported near the MDL or IDL provide insight to site conditions, quality assurance dictates that analytical methods achieve a consistently reliable level of detection known as the practical quantitation limit (PQL). The contract laboratory will provide numerical results for all analytes and report them as detected above the PQL or undetected at the PQL.

Achieving a stated detection limit for a given analyte is helpful in providing statistically useful data. Intended data uses, such as comparison to numerical criteria or risk assessments, typically dictate specific project target detection limits (TDLs) necessary to fulfill stated objectives. Table 5 provides a list of specific TDLs based primarily on numerical criteria derived from *Cleanup Levels and Risk Calculations (CLARC) under the Model Toxics Control Act Cleanup Regulation, Version 3.1* found at [http://www.ecy.wa.gov/programs/tcp/tools/CLARC v 3.1/clarc v 3_1.htm](http://www.ecy.wa.gov/programs/tcp/tools/CLARC_v_3.1/clarc_v_3_1.htm). Other criteria

include State of Washington (WAC 173-201) and federal Ambient Water Quality Criteria (AWQC). The analytical methods and processes selected will provide PQLs less than the TDLs under ideal conditions. However, the detection limits presented in Table 5 are considered targets because several factors may influence final detection limits. First, moisture and other physical conditions of soil affect detection limits. Second, analytical procedures may require sample dilutions or other practices to accurately quantify a particular analyte at concentrations above the range of the instrument. The effect is that other analytes could be reported as undetected but at a value much higher than a specified TDL. Data users must be aware that high non-detect values, although correctly reported, can bias statistical summaries and careful interpretation is required to correctly characterize site conditions.

10.2.3 Precision

Precision is the measure of mutual agreement among replicate or duplicate measurements of an analyte from the same sample and applies to field duplicate or split samples, replicate analyses, and duplicate spiked environmental samples (matrix spike duplicates). The closer the measured values are to each other, the more precise the measurement process. Precision error may affect data usefulness. Good precision is indicative of relative consistency and comparability between different samples. Precision will be expressed as the relative percent difference (RPD) for spike sample comparisons of various matrices and field duplicate comparisons for water samples. This value is calculated by:

$$RPD(\%) = \frac{|D_1 - D_2|}{(D_1 + D_2)/2} \times 100,$$

Where

D₁ = Concentration of analyte in sample.
D₂ = Concentration of analyte in duplicate sample.

The calculation applies to split samples, replicate analyses, duplicate spiked environmental samples (matrix spike duplicates), and laboratory control duplicates. The RPD will be calculated for samples and compared to the applicable criteria. Precision can also be expressed as the percent difference (%D) between replicate analyses. Persons performing the evaluation must review one or more pertinent documents (USEPA February 1994; USEPA 1986; or USEPA 1983) that address criteria exceedances and courses of action. Relative percent difference goals for this effort is 30 percent in water and 40 percent in soil for all analyses.

10.2.4 Accuracy

Accuracy is a measure of bias in the analytic process. The closer the measurement value is to the true value, the greater the accuracy. This measure is defined as the difference between the reported value versus the actual value and is often measured with the addition of a known compound to a sample. The amount of known compound reported in the sample, or percent

recovery, assists in determining the performance of the analytical system in correctly quantifying the compounds of interest. Since most environmental data collected represent one point spatially and temporally rather than an average of values, accuracy plays a greater role than precision in assessing the results. In general, if the percent recovery is low, non-detect results may indicate that compounds of interest are not present when in fact these compounds are present. Detected compounds may be biased low or reported at a value less than actual environmental conditions. The reverse is true when recoveries are high. Non-detect values are considered accurate while detected results may be higher than the true value.

Accuracy will be expressed as the percent recovery of a surrogate compound (also known as “system monitoring compound”), a matrix spike result, or from a standard reference material where:

$$\text{Recovery (\%)} = \frac{\text{Sample Result}}{\text{Spike Amount}} \times 100$$

Persons performing the evaluation must review one or more pertinent documents (USEPA February 1994; USEPA 1986; or USEPA 1983) that address criteria exceedances and courses of action. Accuracy criteria for surrogate spikes, matrix spikes, and laboratory control spikes are found in Table 6, Table 7, and Table 8 of this work plan, respectively.

10.2.5 Representativeness, Completeness and Comparability

Representativeness expresses the degree to which data accurately and precisely represent the actual site conditions. The determination of the representativeness of the data will be performed by completing the following:

- Comparing actual sampling procedures to those delineated within the SAP and this QAPP.
- Comparing analytical results of field duplicates to determine the variations in the analytical results.
- Invalidating nonrepresentative data or identifying data to be classified as questionable or qualitative. Only representative data will be used in subsequent data reduction, validation, and reporting activities.

Completeness establishes whether a sufficient amount of valid measurements were obtained to meet project objectives. The number of samples and results expected establishes the comparative basis for completeness. Completeness goals are 90 percent useable data for samples/analyses planned. If the completeness goal is not achieved an evaluation will be made to determine if the data are adequate to meet study objectives. The anticipated number of samples and analyses are presented in Table 1.

Comparability expresses the confidence with which one set of data can be compared to another. Although numeric goals do not exist for comparability, a statement on comparability will be prepared to determine overall usefulness of data sets, following the determination of both precision and accuracy.

10.2.6 Holding Times

Holding times are defined as the time between sample collection and extraction, sample collection and analysis, or sample extraction and analysis. Some analytical methods specify a holding time for analysis only. For many methods, holding times may be extended by sample preservation techniques in the field. If a sample exceeds a holding time, then the results may be biased low. For example, if the extraction holding time for volatile analysis of soil sample is exceeded, then the possibility exists that some of the organic constituents have volatilized from the sample or degraded. Results for that analysis will be qualified as estimated to indicate that the reported results may be lower than actual site conditions. Holding times are presented in Table 9.

10.2.7 Blanks

According to the *National Functional Guidelines for Organic Data Review* (USEPA 1994), “The purpose of laboratory (or field) blank analysis is to determine the existence and magnitude of contamination resulting from laboratory (or field) activities. The criteria for evaluation of blanks apply to any blank associated with the samples (e.g., method blanks, instrument blanks, trip blanks, and equipment blanks).” Trip blanks are placed with samples during shipment; method blanks are created during sample preparation and follow samples throughout the analysis process.

Analytical results for blanks will be interpreted in general accordance with *National Functional Guidelines for Organic Data Review* and professional judgment.

10.3 SAMPLE COLLECTION, HANDLING AND CUSTODY

10.3.1 Sampling Equipment Decontamination

The drilling equipment will be decontaminated before beginning each exploration using a hot-water pressure washer. Reusable sampling/monitoring equipment (trowels, split-spoons, hand augers, etc.) that comes in contact with soil or groundwater will be decontaminated before each use. Decontamination procedures for this equipment will consist of the following: (1) wash with nonphosphate detergent solution (Liqui-Nox and distilled water), (2) rinse with distilled water, and (3) place the decontaminated equipment on clean plastic sheeting or in a plastic bag. Field personnel will limit cross-contamination by changing gloves between sampling events. Wash water used to decontaminate the sampling equipment will be stored on-site in labeled 55-gallon drums for subsequent characterization and disposal.

In addition to the decontamination procedures described above, sampling equipment that has visible petroleum product staining will be decontaminated by steam cleaning and/or as follows:

- Wash with brush and Liqui-Nox soap.
- Rinse with potable water.
- Wash with ethyl-alcohol.
- Rinse with distilled water.

10.3.2 Sample Containers and Labeling

The Field Coordinator will establish field protocol to manage field sample collection, handling, and documentation. Soil samples obtained during this study will be placed in

appropriate laboratory-prepared containers. Sample containers and preservatives are listed in Table 9.

Sample containers will be labeled with the following information at the time of collection: (1) project name and number, (2) sample name, which will include a reference to depth if appropriate, and (3) date and time of collection.

The sample collection activities will be noted in the field log books. The Field Coordinator will monitor consistency between the SAP, sample containers/labels, field log books, and the chain-of-custody.

10.3.3 Sample Storage

Samples will be placed in a cooler with “blue ice” immediately after they are collected. The objective of the cold storage will be to attain a sample temperature of 4 degrees Celsius. Holding times will be observed during sample storage. Holding times for the project analyses are summarized in Table 9.

10.3.4 Sample Shipment

The samples will be transported and delivered to the analytical laboratory in the coolers. Field personnel will transport and hand deliver samples that are being submitted to a local laboratory for analysis. Samples that are being submitted to an out-of-town laboratory for analysis will be transported by a commercial express mailing service on an overnight basis. The Field Coordinator will monitor that the shipping container (cooler) has been properly secured using clear plastic tape and custody seals.

10.3.5 Chain-of-Custody Records

Field personnel are responsible for the security of samples from the time the samples are taken until the samples have been received by the shipper or laboratory. A chain-of-custody (COC) form will be completed at the end of each field day for samples being shipped to the laboratory. Information to be included on the COC form include:

- Project name and number.
- Sample identification number.
- Date and time of sampling.
- Sample matrix (soil, water, etc.) and number of containers from each sampling point, including preservatives used.
- Depth of subsurface soil sample.
- Analyses to be performed.
- Names of sampling personnel and transfer of custody acknowledgment spaces.
- Shipping information including shipping container number.

The original COC record will be signed by a member of the field team and bear a unique tracking number. Field personnel shall retain carbon copies and place the original and remaining copies in a plastic bag, taped to the inside lid of the cooler before sealing the container for shipment. This record will accompany the samples during transit by carrier to the laboratory.

10.3.6 Laboratory Custody Procedures

The laboratory will follow their standard operating procedures (SOPs) to document sample handling from time of receipt (sample log-in) to reporting. Documentation will include at a minimum, the analysts name or initial, time, and date.

10.3.7 Field Documentation

Field documentation provides important information about potential problems or special circumstances surrounding sample collection. Field personnel will maintain daily field logs while on-site. The field logs will be prepared on field report forms or in a bound logbook. Entries in the field logs and associated sample documentation forms will be made in waterproof ink, and corrections will consist of line-out deletions that are initialed and dated. Individual logbooks will become part of the project files at the conclusion of this field exploration.

At a minimum, the following information will be recorded during the collection of each sample:

- Sample location and description
- Site or sampling area sketch showing sample location and measured distances
- Sampler's name(s)
- Date and time of sample collection
- Designation of sample as composite or discrete
- Type of sample (soil or water)
- Type of sampling equipment used
- Field instrument readings
- Field observations and details that are pertinent to the integrity/condition of the samples (e.g., weather conditions, performance of the sampling equipment, sample depth control, sample disturbance, etc.)
- Preliminary sample descriptions (e.g., lithologies, noticeable odors, colors, field screening results)
- Sample preservation
- Shipping arrangements (overnight air bill number)
- Name of recipient laboratory

In addition to the sampling information, the following specific information also will be recorded in the field log for each day of sampling:

- Team members and their responsibilities
- Time of arrival/entry on Site and time of Site departure
- Other personnel present at the Site
- Summary of pertinent meetings or discussions with regulatory agency or contractor personnel
- Deviations from sampling plans, Site safety plans, and QAPP procedures
- Changes in personnel and responsibilities with reasons for the changes
- Levels of safety protection
- Calibration readings for any equipment used and equipment model and serial number

The handling, use, and maintenance of field log books are the field coordinator's responsibilities.

10.4 CALIBRATION PROCEDURES

10.4.1 Field Instrumentation

Equipment and instrumentation calibration facilitates accurate and reliable field measurements. Field and laboratory equipment used on the project will be calibrated and adjusted in general accordance with the manufacturer's recommendations. Methods and intervals of calibration and maintenance will be based on the type of equipment, stability characteristics, required accuracy, intended use, and environmental conditions. The basic calibration frequencies are described below.

The photo or flame-ionization detector (PID/FID) used for vapor measurements will be calibrated daily for site safety monitoring purposes in general accordance with the manufacturer's specifications. The calibration results will be recorded in the field logbook.

The Horiba U-22 water quality measuring system and Hach DR/2010 spectrophotometer used for measuring monitored natural attenuation parameters will be calibrated prior to each monitoring event in general accordance with the manufacturer's specifications. The calibration results will be recorded in the field report.

10.4.2 Laboratory Instrumentation

For analytical chemistry, calibration procedures will be performed in general accordance with the methods cited and laboratory standard operating procedures. Calibration documentation will be retained at the laboratory and readily available for a period of six months.

10.5 ANALYTICAL PROCEDURES

10.5.1 SVOCs by EPA Method SW-846 8270C

This method can quantify most neutral, acidic, and basic SVOCs that are soluble in methylene chloride by gas chromatography/mass spectrometry (GC/MS), capillary column technique, including PAHs and chlorinated phenols. Soil samples submitted for analysis of SVOCs will be tested for the specific compounds identified in Table 5 using EPA Method 8270C. Groundwater samples require lower detection limits than that provided by the basic analytical method. Therefore, groundwater samples submitted for analysis of the SVOC compounds identified in Table 5 will be tested using a combination of 8270C methods - select ion monitoring (SIM) and large volume injection (LVI). If groundwater samples at given locations demonstrate relatively high analyte concentrations and routinely require dilutions, method 8270C without SIM or LVI may be employed. It should be noted that, in these instances, detection limits for constituents of concern will be elevated.

10.5.2 BETX by EPA Method SW-846 8260B

Though capable of quantifying dozens of analytes, this analysis will be run specifically for benzene, ethylbenzene, toluene, and xylenes. There are various techniques by which these compounds may be introduced into the GC/MS system. Purge-and-trap, by Methods 5030

(aqueous samples) and 5035 (solid and waste oil samples), is the most commonly used technique for volatile organic analytes. However, other techniques are also appropriate and necessary for some analytes. These include direct injection following dilution with hexadecane (Method 3585) for waste oil samples; automated static headspace by Method 5021 for solid samples; direct injection of an aqueous sample (concentration permitting) or injection of a sample concentrated by azeotropic distillation (Method 5031); and closed system vacuum distillation (Method 5032) for aqueous, solid, oil and tissue samples.

This method was selected over Method SW-846 8021 because of the possibility of false positives for samples containing elevated concentrations of other constituents.

10.5.3 Diesel- and Heavy Oil-Range Hydrocarbons Using Ecology Method NWTPH-Dx

The method involves extracting the samples with methylene chloride and injecting a portion of the extract into a gas chromatograph (GC) equipped with a flame ionization detector (FID). This method specifies criteria for the identification and quantitation of semivolatile petroleum products. A cleanup procedure will be used to aid in the removal of non-petroleum based organic interferences (i.e. biogenic interferences). When the type of petroleum product is unknown, #2 diesel initially will be used as the default petroleum standard. The reporting limits are 25 milligrams per kilogram (mg/kg) for soil and 0.25 milligrams per liter (mg/l) for water for petroleum products that elute in the range of jet fuels through #2 diesel. For petroleum products eluting after #2 diesel oil (e.g. motor oils, hydraulic fluids, and heavy fuel oils), the reporting limits are 100 mg/kg for soil and 0.50 mg/l for water. All soil analytical results are reported on a dry weight basis.

10.5.4 Extractable Petroleum Hydrocarbons (EPH) Using Ecology-Specified Method

This method is designed to measure the collective concentrations of extractable aliphatic and aromatic petroleum hydrocarbons in water and soil. The carbon ranges used are given in equivalent carbon numbers (EC) which are related to the boiling point of a chemical normalized to the boiling point of the n-alkanes and its retention time in a boiling point gas chromatographic column. Extractable aliphatic hydrocarbons are collectively quantitated within five ranges: C8 through C10, >C10 through C12, >C12 through C16, >C16 through C21 and >C21 through C34. Extractable aromatic hydrocarbons are collectively quantitated within five ranges: C8 through C10, >C10 through C12, >C12 through C16, >C16 through C21 and >C21 through C34.

Petroleum products suitable for evaluation by this method include, but are not limited to, kerosene and jet fuels, diesel and fuel oils and hydraulic, insulating and lubricating oils.

10.5.5 Dioxins/Furans by EPA Method SW-846 8290A

This method calls for the use of high-resolution gas chromatography and high-resolution mass spectrometry (HRGC/HRMS) on purified sample extracts. Samples containing concentrations of specific congeneric analytes (PCDDs and PCDFs) considered within the scope

of this method that are greater than ten times the upper MDLs must be analyzed by a protocol designed for such concentration levels, e.g., Method 8280.

10.5.6 Total/Dissolved Metals by EPA Methods 6000/7000 Series

Metals will be quantified using either graphite furnace atomic absorption spectroscopy or inductively coupled plasma with mass spectrometry (ICPMS). The choice of method depends primarily on the detection limit needed. Metals to be analyzed by SW-846 6020 (ICPMS) include arsenic (As), total chromium (Cr) and copper (Cu). Hexavalent chromium [Cr (VI)] will be quantified by SW-846 7196A (colorimetric analysis).

10.5.7 Nitrate by EPA Method 353.2

This method analyzes a filtered sample passed through a column containing granulated copper cadmium to reduce nitrate to nitrite. The nitrite (that was originally present plus reduced nitrate) is determined by diazotizing with sulfanilamide and coupling with n-(1-naphthyl)-ethylenediamine dihydrochloride to form a highly colored azo dye which is measured colorimetrically. Separate, rather than combined nitrate-nitrite, values are readily obtained by carrying out the procedure first with, and then without, the Cu-Cd reduction step.

10.5.8 Sulfate by EPA Method 300.0

A small volume of sample is introduced into an ion chromatograph. The anions of interest are separated and measured, using a system comprised of a guard column, analytical column, suppressor device, and conductivity detector. Method interferences may be caused by contaminants in the reagent water, reagents, glassware, and other sample processing apparatus that lead to discrete artifacts or elevated baselines in an ion chromatogram. These interferences can lead to false positive results for target analytes as well as reduced detection limits as a consequence of elevated baseline noise.

10.5.9 Dissolved Inorganic Carbon/Total Organic Carbon by EPA Method 415.1

The method is most applicable to measurement of organic carbon above 1 mg/L. Organic carbon in a sample is converted to carbon dioxide (CO₂) by catalytic combustion or wet chemical oxidation. The CO₂ formed can be measured directly by an infrared detector or converted to methane (CH₄) and measured by a flame ionization detector. The amount of CO₂ or CH₄ is directly proportional to the concentration of carbonaceous material in the sample. The primary difference between dissolved inorganic and total organic carbon is the sample preparation, whereby the dissolved inorganic portion is filtered and treated prior to analysis.

10.6 DATA REPORTING AND LABORATORY DELIVERABLES

Laboratories will report data in formatted hardcopy and digital form. Analytical laboratory measurements will be recorded in standard formats that display, at a minimum, the field sample identification, the laboratory identification, reporting units, qualifiers, analytical method, analyte tested, analytical result, extraction and analysis dates, and detection limit (PQL only). Each

sample delivery group will be accompanied by sample receipt forms and a case narrative identifying data quality issues. Laboratory electronic data deliverables (EDD) will be established by GeoEngineers, Inc., with the contract laboratory. Final results will be sent to the Project Manager.

Chromatograms will be provided for every sample analyzed using Ecology Method NWTPH-Dx. The laboratory will assure that the full height of all peaks appear on the chromatograms and that the same horizontal time scale is used to allow for comparisons to other chromatograms.

10.7 INTERNAL QUALITY CONTROL

10.7.1 Field Quality Control

Field QC samples serve as a control and check mechanism to monitor the consistency of sampling methods and the influence of off-site factors on environmental samples. Off-site factors include airborne volatile organic compounds and potable water used in drilling activities.

Equipment Rinsates

Equipment rinsates indicate if sampling equipment decontamination procedures are performed adequately between adjacent sampling locations. Cross contamination may occur if equipment is not thoroughly cleaned between samples. One equipment rinsate of a commonly used sampling apparatus (split spoon sampler, stainless steel spoons, etc.) will be collected during the field exploration activities. The rinsate will be collected after cleaning and decontaminating the sampling apparatus under normal operating conditions. A rinsate sample will be collected by pouring HPLC-grade water over the apparatus and into the sample containers. The rinsate will be collected between two sampling locations on the same day.

Field Duplicates

In addition to replicate analyses performed in the laboratory, field duplicates also serve as measures for precision. Under ideal field conditions, field duplicates (referred to as splits), are created when a volume of the sample matrix is thoroughly mixed, placed in separate containers, and identified as different samples. This tests both the precision and consistency of laboratory analytical procedures and methods, and the consistency of the sampling techniques used by field personnel.

One field duplicate will be collected during each groundwater monitoring event. Field duplicates will not be collected for other sample matrices.

Trip Blanks

Trip blanks accompany volatile organic analysis sample containers during shipment and sampling periods. Contamination of a trip blank indicates exposure during sampling and handling that may contribute additional compounds to the original environmental sample. For this project, the greatest concern of non-site influences are the sample containers. Samples could be contaminated by diffusion of organics (particularly chlorofluorocarbon and methylene

chloride) through the sample container. A minimum of one trip blank will accompany samples for BETX analysis.

Generally, trip blanks are prepared at the laboratory and are shipped to the field location with the other sample containers. One trip blank accompanies each sampling team throughout the sampling activities that include traveling to sampling locations, sampling, sample packaging and shipment. Therefore, if two teams are sampling, each team will carry a trip blank during their sampling activities and the trip blank each team carries will be associated with the samples that they collected.

10.7.2 Laboratory Quality Control

Laboratory quality control procedures will be evaluated through a formal data validation process. The analytical laboratory will follow standard method procedures that include specified QC monitoring requirements. These requirements will vary by method but generally include:

- method blanks
- internal standards
- calibrations
- matrix spike/matrix spike duplicates (MS/MSD)
- laboratory control spikes/spike duplicates (LCS/LCSD)
- laboratory replicates or duplicates
- surrogate spikes

Laboratory Blanks

Laboratory procedures employ the use of several types of blanks but the most commonly used blank for QA/QC assessments are method blanks. Method blanks are laboratory quality control (QC) samples that consist of either a soil like material having undergone a contaminant destruction process or HPLC water. Method blanks are extracted and analyzed with each batch of environmental samples undergoing analysis. Method blanks are particularly useful during volatile analysis since volatile compounds can be transported in the laboratory through the vapor phase. If a substance is found in the method blank then one (or more) of the following occurred:

- Measurement apparatus or containers were not properly cleaned and contained contaminants.
- Reagents used in the process were contaminated with a substance(s) of interest.
- Contaminated analytical equipment was not properly cleaned.
- Volatile substances in the air with high solubility or affinities toward the sample matrix contaminated the samples during preparation or analysis.

It is difficult to determine which of the above scenarios took place if blank contamination occurs. However, it is assumed that the conditions that affected the blanks also likely affected the project samples. Given method blank results, validation rules assist in determining which substances in samples are considered “real,” and which ones are attributable to the analytical process. Furthermore, the guidelines state, “. . . there may be instances where little or no

contamination was present in the associated blank, but qualification of the sample is deemed necessary. Contamination introduced through dilution water is one example.”

Calibrations

Several types of calibrations are used, depending on the method, to determine whether the methodology is ‘in control’ by verifying the linearity of the calibration curve and to assure that the sample results reflect accurate and precise measurements. The main calibrations used are initial calibrations, daily calibrations, and continuing calibration verification.

Matrix Spike/Matrix Spike Duplicates (MS/MSD)

Matrix spike/spike duplicate samples are used to assess influences or interferences caused by the physical or chemical properties of the sample itself. For example, extreme pH affects the results of SVOCs. Or, the presence of a particular compound may interfere with accurate quantitation of another analyte. MS/MSD data is reviewed in combination with other QC monitoring data to determine matrix effects. In some cases, matrix affects cannot be determined due to dilution and/or high levels of related substances in the sample. A matrix spike is evaluated by spiking a known amount of one or more of the target analytes ideally at a concentration of 5 to 10 times higher than the sample result. A percent recovery is calculated by subtracting the sample result from the spike result, dividing by the spiked amount, and multiplying by 100.

The samples for the MS and MSD analyses should be collected from a boring or sampling location that is believed to exhibit low-level contamination. A sample from an area of low-level contamination is needed because the objective of MS/MSD analyses is to determine the presence of matrix interferences, which can best be achieved with low levels of contaminants. Additional sample volume will be collected for these analyses. This MS/MSD sample will be a composite to achieve a level of representativeness and reproducibility in the data.

Laboratory Control Spikes/Spike Duplicates (LCS/LCSD)

Also known as blanks spikes, laboratory control spikes are similar to matrix spikes in that a known amount of one or more of the target analytes are spiked into a prepared media and a percent recovery of the spiked substances are calculated. The primary difference between a matrix spike and LCS is that the LCS spike media is considered “clean” or contaminant free. For example, HPLC water is typically used for LCS water analyses. The purpose of an LCS is to help assess the overall accuracy and precision of the analytical process including sample preparation, instrument performance, and analyst performance. LCS data must be reviewed in context with other controls to determine if out-of-control events occur.

Laboratory Replicates/Duplicates

Laboratories often utilize MS/MSDs, LCS/LCSDs, and/or replicates to assess precision. Replicates are a second analysis of a field collected environmental sample. Replicates can be split at varying stages of the sample preparation and analysis process, but most commonly occur as a second analysis on the extracted media.

Surrogate Spikes

The purposes of using a surrogate are to verify the accuracy of the instrument being used and extraction procedures. Surrogates are substances similar to, but not one of, the target analytes. A known concentration of surrogate is added to the sample and passed through the instrument, noting the surrogate recovery. Each surrogate used has an acceptable range of percent recovery. If a surrogate recovery is low, sample results may be biased low and depending on the recovery value, a possibility of false negatives may exist. Conversely, when recoveries are above the specified range of acceptance a possibility of false positives exist, although non-detected results are considered accurate.

10.8 DATA REDUCTION AND ASSESSMENT PROCEDURES

10.8.1 Data Reduction

Data reduction involves the conversion or transcription of field and analytical data to a useable format. The laboratory personnel will reduce the analytical data for review by the Quality Assurance Leader and Project Manager.

10.8.2 Field Measurement Evaluation

Field data will be reviewed at the end of each day by following the quality control checks outlined below and procedures in the SAP. Field data documentation will be checked against the applicable criteria as follows:

- Sample collection information.
- Field instrumentation and calibration.
- Sample collection protocol.
- Sample containers, preservation and volume.
- Field QC samples collected at the frequency specified.
- Sample documentation and chain of custody (COC) protocols.
- Sample shipment.

Cooler receipt forms and sample condition forms provided by the laboratory will be reviewed for out-of-control incidents. The final report will contain what effects, if any, an incident has on data quality. Sample collection information will be reviewed for correctness before inclusion in a final report.

10.8.3 Field Quality Control Evaluation

A field quality control evaluation will be conducted by reviewing field log books and daily reports, discussing field activities with staff, and reviewing field QC samples (trip blanks, equipment rinsates, and field duplicates). Trip blanks and equipment rinsates will be evaluated using the same criteria as method blanks.

Precision for field duplicate soil samples will not be evaluated because even a well mixed sample is not entirely homogenous due to sampling procedures, soil conditions, and contaminant transport mechanisms.

10.8.4 Laboratory Data Quality Control Evaluation

The laboratory data assessment will consist of a formal review of the following quality control parameters, utilizing criteria identified in Section 10.2:

- Holding times
- Method blanks
- Matrix spike/spike duplicates
- Laboratory control spikes/spike duplicates
- Surrogate spikes
- Replicates

In addition to these quality control mechanisms, other documentation such as cooler receipt forms and case narratives will be reviewed to fully evaluate laboratory QA/QC.

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APPENDIX A
HISTORICAL MAPS AND AERIAL PHOTOGRAPHS

APPENDIX B
SUMMARY OF GROUNDWATER MONITORING RESULTS

APPENDIX C
CORNWALL SITE PLAN
(LANDAU, 2003)

APPENDIX D
HEALTH AND SAFETY PLAN